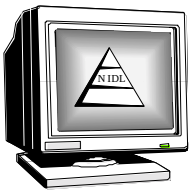

NIDL is assisting Office of Americas with a color monitor for their tasks. Much of their work is in stereo and a low stereo refresh rate can lead to flicker that causes eyestrain. NIDL does not certify the ViewSonic P815-4M color monitor as being suitable for IEC workstations requiring a stereo-capable 1024 x 1024 pixel addressability color monitor. We rate the monitor "C" for stereo because it can achieve only 110 Hz vertical refresh rate at 1024 x 1024 pixel addressability, rather than the IEC Working Group specified 120 Hz. For this addressability and 110 Hz refresh rate, the stereo extinction ratio is 10 to 1 for the ZScreen and 15 to 1 with CrystalEyes active glasses. The only way the ViewSonic P815 monitor can achieve a 120 Hz refresh rate is by reducing the addressability. Reducing the addressability to 1152 x 864 pixels allows the monitor to achieve a 128 Hz vertical refresh rate with a signal generator, or with a PC and a Matrox G450 graphics card. The monitor apparently can achieve only 118 Hz at 1152 x 864 addressability using the Lockheed-Martin supplied workstation and the SocetSet software. The 118 Hz refresh rate may be limited by the system; it is not limited by the monitor at the 1152 x 864 pixel addressability. The difference between the 118 and 120 Hz vertical refresh rate probably is not a significant difference based on the human visual system and the perception of flicker. The smaller area associated with 864 horizontal lines may reduce image analysts' productivity compared to the larger 1024-line image. We visited the Office of Americas site on October 11, 2001 and found that the ViewSonic monitor looks good and analysts seem to be satisfied with its performance.

Quick Look at the ViewSonic P815-4M (Lockheed Martin 2001) 4 x 3 Aspect Ratio, 21-Inch Diagonal Color CRT Monitor for Stereo

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CONTENTS

NIDL IEC Monitor Certification Report

The ViewSonic P815-4M Color CRT Monitor

FINAL GRADES
Monoscopic Mode: Not Rated
Stereoscopic Mode: C

A=Substantially exceeds IEC Requirements; B= Meets IEC Requirements; C=Nearly meets IEC Requirements; F=Fails to meet IEC Requirements in a substantial way.

NIDL does not certify the ViewSonic P815-4M color monitor as being suitable for IEC workstations requiring a stereo-capable 1024 x 1024 pixel addressability color monitor. We rate the monitor "C" because it can achieve only 110 Hz vertical refresh rate at 1024 x 1024 pixel addressability, rather than the IEC Working Group specified 120 Hz. Monitors passing the IEC stereo 120 Hz specification are listed in Table 1.

NIDL had earlier tested and certified the 21 inch ViewSonic P817 color monitor for both monoscopic and stereoscopic-modes in IEC workstations; it could achieve 120 Hz vertical refresh rate in stereo at 1024 x 1024 addressability. Unfortunately, ViewSonic withdrew the P817 monitor from production, but advised Lockheed Martin that the P815-4 is a suitable replacement. Lockheed Martin placed these ViewSonic Model P815-4 monitors at the Office of Americas for use by the geospatial information (GI) specialists for stereo viewing. The system is a Dell Precision 633 computer with SocetSet software and a 3D Labs Oxygen GVX graphics card. NIDL contacted a Government POC (Chris R.) at Office of Americas who said that flicker at 80 Hz refresh rate is painful and is still somewhat noticeable at 110 Hz. He selected 1152 x 864 pixel addressability in order to maximize the vertical refresh rate to 118 Hz as the best compromise between addressability and near flicker-free stereo. The difference between the 118 and 120 Hz vertical refresh rate is probably not significant based on the human visual system and the perception of flicker. The significant difference is that the P815-4 cannot do 1024 lines at 120 Hz. It can do 1152 x 864 lines. The smaller area associated with 864 horizontal lines may reduce productivity compared to the larger 1024-line image. NIDL visited the Office of Americas site on October 11, 2001 and found that the ViewSonic monitor looks good and users seem to be satisfied with its performance.

Details of this evaluation are summarized below:

Refresh Rates with Signal Generator in Stereoscopic Mode

- Vertical refresh rate for the 1024 x 1024 stereo format was 110 Hz, limited by the monitor.
- Vertical refresh rate for the 1152 x 864 stereo format used by Office of Americas was 128 Hz vertical, limited by the maximum horizontal scan rate.

	Stereoscopic Modes	
Addressability	1152 x 864 *	1024 x 1024
Vertical Scan	128.9 Hz *	110 Hz
Horizontal Scan	116 kHz *	117.310 kHz

* ViewSonic P815-2M monitor, Serial number QE73402103 manufactured August 1997.

Refresh Rates with PC and Matrox G450 Graphics Card in Stereo

- NIDL measured a maximum vertical refresh rate of 128 Hz for the 1152 x 864 stereo format. The vertical refresh rate is limited by the maximum horizontal scan rate (116 kHz) of the monitor when using the PC and graphics card.

Extinction Ratio in Stereo

- Using the StereoGraphics ZScreen and passive glasses, stereo extinction ratio averaged 10 to 1 (11.4 left, 9.0 right) at screen center.
- Using the StereoGraphics CrystalEyes active shutter glasses, stereo extinction ratio averaged 15 to 1 (15.3 left, 14.8 right) at screen center.

Table 1. NIDL IEC Color Monitor Certified for Stereoscopic-Mode Application (Have Rating B or Higher for Both Monoscopic and Stereoscopic Modes)

Monitor	IEC Spec	Corner stone	EIZO	Hitachi	Siemens	ViewSonic
Model		P1700	F980	CM814	SCM21130	P817
Certified for stereoscopic*		Y	Y	Y	Y	Y
Monoscopic		A	B	B	B	B
Stereoscopic		B	B	B	B	B
Cm, Zone A	25%	57%	37%	35%	36%	29%
Cm, Zone B	20%	52%	27%	30%	21%	40%
Refresh per eye	60 Hz	60 Hz	60 Hz	60 Hz	60.5 Hz	60 Hz
Extinction ratio, panel	No spec	10.6	12.6	11.2	11.2	10.1
IR glasses	15 to 1	21.0	14.3		18.1	
Price		$1363	$1790	$1200	< $2800	$1600

* Certified by NIDL requires achieving a rating of “B” or above for stereoscopic and for monoscopic performance relative to the IEC Working Group specifications listed in the Evaluation Datasheet. This summary is a compilation of ratings for color monitors from previously NIDL IEC monitor reports.

Evaluation Datasheet

ViewSonic P815-4

Mode	IEC Requirement	Measured Performance	Compliance
MONOSCOPIC			
Addressability	1024 x 1024 min.	1600 x 1200	Pass
Contrast Ratio (Dynamic Range)	300:1 (24.8 dB)	311:1 (24.9 dB)	Pass
Luminance (Lmin)	0.1 fL ± 4% min.	0.107 fL	Pass
Luminance (Lmax)	30 fL ± 4%	33.27 fL	Pass
Uniformity (Lmax)	20% max.	10.8%	Pass
Halation	3.5% max.	Not measured	
Color Temp	6500 to 9300 K ± 0.01 Δu'v' max.	8326 K, 9629 K	Pass
Reflectance	Not specified	Not measured	
Bit Depth	8-bit± 5 counts	Not measured	
Step Response	No visible ringing	Clean	Pass
Uniformity (Chromaticity)	0.010 ± 0.005 Δu'v' max.	Not measured	
Pixel aspect ratio	Square, H = V± 6%	Not measured	
Screen size, viewable diagonal	17.5 to 24 inches ± 2 mm	Not measured	
Raster Modulation			
Center Screen, Lmax	Not specified	Cm = 36%	
Center Screen, 50% Lmax	Not specified	Cm = 65%	
Cm, Zone A, 7.6"	25% min.	Not measured	
Cm, Zone A, 9.8”	25% min.	Not measured	
Cm, Zone B	20% min.	Not measured	
Pixel density	72 ppi min.	Not measured	
Moiré, phosphor-to-pixel spacing	1.0 max	Not measured	
Straightness	0.5% max ± 0.05 mm	Not measured	
Linearity	1.0% ± 0.05 mm max	0.82%	Pass
Jitter	2 ± 2 mils max.	Not measured	
Swim, Drift	5 ± 2 mils max.	Not measured	
Warm-up time, Lmin to +/- 50%	30 ± 0.5 mins. max	Not measured	
Warm-up time, Lmin to +/- 10%	60 ± 0.5 mins. max	Not measured	N/A
Refresh	72 ±1 Hz min. 60 ±1 Hz absolute min	Set to 85 Hz	Pass
STEREOSCOPIC			
Addressability	1024 x 1024 min.	1024 x 1024	Pass
Lmin	Not specified	0.1 fL	
Lmax	6 fL min ± 4%	5.05 fL (Z) , 5.86 (IR)	Pass
Dynamic range	17.7 dB min	17.0 dB (Z) , 17.7 dB (IR)	Pass
Uniformity (Chromaticity)	0.02 ± 0.005 Δu'v' max	0.008 Δu'v'	Pass
Refresh rate	60 Hz per eye, min	55 Hz per eye	Fail
Extinction Ratio	15:1 min	10.2:1 (Z), 15:1 (IR)	Pass
AMBIENT LIGHTING			
Dynamic range = 22 dB (158:1)	N/A	Not measured	
Dynamic range = 17.1 dB (51:1)	N/A	Not measured	

(Z) Denotes StereoGraphics ZScreen and Eyewear
(IR) Denotes StereoGraphics CrystalEyes IR Eyewear

Section I INTRODUCTION

The National Information Display Laboratory (NIDL) was established in 1990 to bring together technology providers - commercial and academic leaders in advanced display hardware, softcopy information processing tools, and information collaboration and communications techniques - with government users. The Sarnoff Corporation in Princeton, New Jersey, a world research leader in high-definition digital TV, advanced displays, computing and electronics, hosts the NIDL.

The present study evaluates a production unit of the ViewSonic P815-4M color CRT high-resolution display monitor supplied to NIDL August 2001 by Lockheed-Martin, Gaithersburg, MD, the IEC contractor. This report is intended for both technical users, such as system integrators, monitor designers, and monitor evaluators, and non-technical users, such as image analysts, software developers, or other users unfamiliar with detailed monitor technology.

The IEC requirements, procedures and calibrations used in the measurements are detailed in the following:

- *NIDL Publication No. 0201099-091***,** *Request for Evaluation Monitors for the National Imagery & Mapping Agency (NIMA) Integrated Exploitation Capability (IEC)*, August 25, 1999.

Two companion documents that describe how the measurements are made are available from the NIDL and the Defense Technology Information Center at http://www.dtic.mil:

- *NIDL Publication No. 171795-036 Display Monitor Measurement Methods under Discussion by EIA (Electronic Industries Association) Committee JT-20 Part 1: Monochrome CRT Monitor Performance Draft Version 2.0. (ADA353605)*

- *NIDL Publication No. 171795-037 Display Monitor Measurement Methods under Discussion by EIA (Electronic Industries Association) Committee JT-20 Part 2: Color CRT Monitor Performance Draft Version 2.0. (ADA341357)*

Other procedures are found in a recently approved standard available from the Video Electronics Standards Association (VESA) at http://www.vesa.org:

- *VESA Flat Panel Display Measurements Standard, Version 1.0, May 15, 1998.*
- *VESA Flat Panel Display Measurements Standard, Version 2.0, June, 2001.*

The IEC workstation provides the capability to display image and other geospatial data on either monochrome or color monitors, or a combination of both. Either of these monitors may be required to support stereoscopic viewing. Selection and configuration of these monitors will be made in accordance with mission needs for each site. NIMA users will select from monitors included on the NIMA-approved Certified Monitor List compiled by the NIDL. The color and monochrome, monoscopic and stereoscopic, monitor requirements are listed in the Evaluation Datasheet.

I.1. The ViewSonic P815-4M Color CRT Monitor

Manufacturer's Specifications

According to ViewSonic Corporation, the specifications as of October 2001 for the Professional Series P815 ViewSonic monitor are listed below. As of January 2003, the web page for ViewSonic at www.viewsonic.com does not list the P815 CRT monitor. The Pro Series model P225 21 inch CRT color monitor that is listed has a higher video bandwidth and horizontal scan frequency than the P815. So, its stereo performance may be better than the P815, but that would have to be determined by experimental measurements.

Manufacturer's specifications for the P815 CRT monitor

- 0.25 mm dot pitch, 0.217 mm horizontal
- 1800 x 1440 pixel maximum, 1600 x 1200 pixels at 92 Hz recommended
- 250 MHz video input bandwidth
- 21 inch (20 inch viewable), 90 degree deflection
- Horizontal frequency 30 to 117 kHz
- Vertical frequency 50 to 180 Hz
- Power requirements 90 to 132 V AC
- Power consumption 148 W
- Misconvergence 0.3 mm max at center, 0.4 mm max at corner
- Operating conditions: temperature 41 to 95 F, 5% to 90% humidity
- Weight 60.5 pounds
- Three year limited warranty on CRT, parts and labor

I.2. Initial Monitor Set Up

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5, p 5.

All measurements will be made with the display commanded through a laboratory grade programmable test pattern generator. The system will be operated in at least a 24 bit mode (as opposed to a lesser or pseudo-color mode) for color and at least 8 bits for monochrome. As a first step, refresh rate should be measured and verified to be at least 72 Hz. The screen should then be commanded to full addressability and Lmin set to 0.1 fL. Lmax should be measured at screen center with color temperature between D65 and D93 allowable and any operator adjustment of gain allowable. If a value >35fL is not achieved (>30 fL for color), addressability should be lowered. For a nominal 1200 by 1600 addressability, addressability should be lowered to 1280 by 1024 or to 1024 by 1024. For a nominal 2048 by 2560 addressability, addressabilities of 1200 x 1600 and 1024 x 1024 can be evaluated if the desired Lmax is not achieved at full addressability.

I.3. Equipment

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 2.0, page 3.

The procedures described in this report should be carried out in a darkened environment such that the stray luminance diffusely reflected by the screen in the absence of electron-beam excitation is less than 0.003 cd/m^2 (1mfL).

Instruments used in these measurements included:

- Quantum Data 8701 400 MHz programmable test pattern signal generator
- Photo Research SpectraScan PR-650 spectroradiometer
- Photo Research SpectraScan PR-704 spectroradiometer
- Minolta LS-100 Photometer
- Minolta CA-100 Colorimeter
- Graseby S370 Illuminance Meter
- Microvision Superspot 100 Display Characterization System which included OM-1 optic module (Two Dimensional photodiode linear array device, projected element size at screen set to 1.3 mils with photopic filter) and Spotseeker 4-Axis Positioner
- Pentium PC with Matrox G450 graphics card

Stereoscopic-mode measurements were made using the following commercially-available stereo products:

- ZScreen 19-inch LCD shutter with passive polarized eyeglasses
- StereoGraphics CrystalEyes IR Eyewear

Section II PHOTOMETRIC MEASUREMENTS

II.1. Contrast Ratio (Dynamic Range)

References: *Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.6, p 6.*

VESA Flat Panel Display Measurements Standard, Version 1.0, May 15, 1998, Section 308-1.

Full screen white-to-black contrast ratio is 311:1 (24.9 dB dynamic range) measured in 1600 x 1200 format in a dark room (Lmax = 33.27 fL , Lmin = 0.107 fL). The monitor passes the IEC specification of 300:1 for a color monitor.

II.2. Maximum Luminance (Lmax)

References: *Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.2, p 6.*

The highest luminance for Lmax was 33.3 fL measured at screen center in 1600 x 1200 x 85 Hz format, and 33.6 fL measured at screen center in 1600 x 1200 x 75 Hz format. The monitor passes the IEC specification of 30 fL for a color monitor.

Objective: Measure the maximum output display luminance.

Equipment: Photometer

Procedure: See dynamic range. Use the value of Lmax defined for the Dynamic Range measurement.

Data: The maximum output display luminance, Lmax, and associated CIE x, y chromaticity coordinates (CIE 1976) were measured using a hand-held colorimeter (Minolta CA-100). The correlated color temperature (CCT) computed from the measured CIE x, y chromaticity coordinates was within range specified by IEC (6500K and 9300K).

Table II.2-1. Maximum Luminance and Color

Color and luminance (in fL) for Full screen at 100% Lmax taken at screen center.

Format	CCT	CIE x	CIE y	Luminance
1600 x 1200 x 85 Hz	9629K	0.281	0.293	33.3 fL
1600 x 1200 x 75 Hz	8326 K	0.287	0.316	33.6 fL

II.3. White Luminance (Lmax) and Color Uniformity

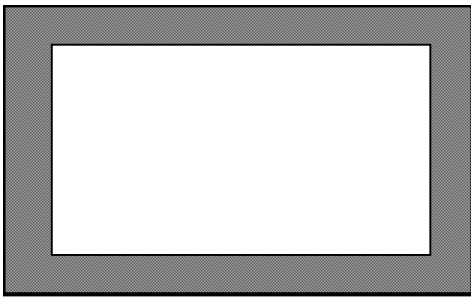
Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 4.4, p. 28.

For 1600 x 1200 monoscopic mode and Lmax = 33.6 fL at screen center, maximum luminance (Lmax) varied by up to 10.8% across the screen. Chromaticity variations were less than 0.006 delta u'v' units. The monitor passes the IEC specifications for uniformity of luminance and chromaticity.

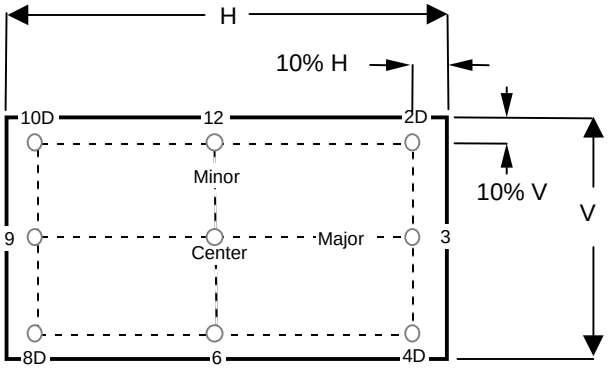
Objective: Measure the variability of luminance and chromaticity coordinates of the white point at 100% Lmax only and as a function of spatial position. Variability of luminance impacts the total number of discriminable gray steps.

Equipment:
- Video generator
- Photometer
- Spectroradiometer or Colorimeter

Test Pattern: Full screen flat field with visible edges at L_{min} as shown in Figure II.3-1.



Full Screen Flat Field test pattern.
Figure II.3-1



Nine screen test locations.
Figure II.3-2

Procedure: Investigate the temporal variation of luminance and the white point as a function of intensity by displaying a full flat field shown in Figure II.3-1 for video input count levels corresponding L_{max}. Measure the luminance and C.I.E. color coordinates at center screen.

Investigate the temporal variation of luminance and the white point as a function of spatial position by repeating these measurements at each of the locations depicted in Figure II.3-2. Define color uniformity in terms of $\Delta u'v'$.

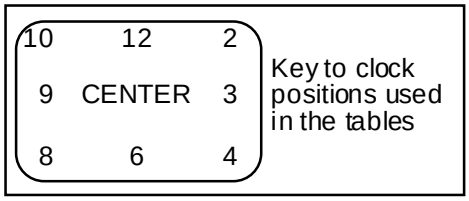
Data: Tabulate the luminance and 1931 C.I.E. chromaticity coordinates (x, y) or correlated color temperature of the white point at each of the nine locations depicted in Figure II.3-2. Additionally, note the location of any additional points that are measured along with the corresponding luminance values.

Table II.3-1.Spatial Uniformity of Luminance and Color

Color and luminance (in fL) for full screen at 100% Lmax taken at nine screen positions.

1600 x 1200

POSITION	CCT	CIE x	CIE y	L, fL
center	8326	0.287	0.316	33.6
2	7979	0.290	0.322	31.0
3	7677	0.294	0.324	30.5
4	8229	0.288	0.317	32.4
6	8563	0.286	0.310	34.2
8	8782	0.284	0.308	33.5
9	8751	0.284	0.309	32.1
10	8087	0.290	0.317	31.4
12	8158	0.289	0.317	33.6



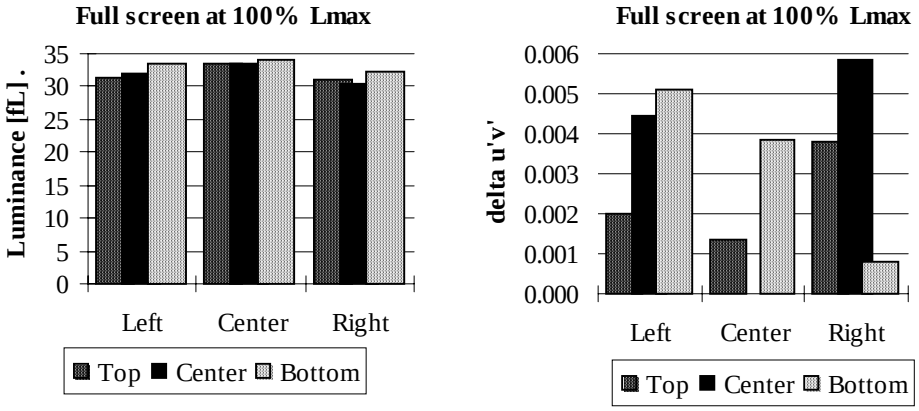


Figure II.3-3. Spatial Uniformity of Luminance Chromaticity. (Delta u'v' of 0.004 is just visible.)

II.4. Halation

Not measured.

II.5. Color Temperature

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 5.4, p 22.

The CCT of the measured white point in monoscopic mode is 9629K at 85 Hz vertical refresh, and 8326 K at 75 Hz vertical refresh which meet IEC specifications.

Objective: Insure measured screen white of a color monitor has a correlated color temperature (CCT) between 6500K and 9300K.

Equipment: Colorimeter

Procedure: Command screen to Lmax. Measure u'v' chromaticity coordinates (CIE 1976).

Data: Coordinates of screen white should be within 0.01 Δu'v' of the corresponding CIE daylight, which is defined as follows: If the measured screen white has a CCT between 6500 and 9300 K, the corresponding daylight has the same CCT as the screen white. If the measured CCT is greater than 9300 K, the corresponding daylight is D93. If the measured CCT is less than 6500 K, the corresponding daylight is D65. The following equations were used to compute Δu'v' values listed in table II.5.1:

1. Compute the correlated color temperature (CCT) associated with (x,y) by the VESA/McCamy formula: CCT = 437 n^3 + 3601 n^2 + 6831 n + 5517, where n = (x-0.3320)/(0.1858 - y). [This is on p. 227 of the FPDM standard]

2. If CCT < 6500, replace CCT by 6500. If CCT > 9300, replace CCT by 9300.

4. Use formulas 5(3.3.4) and 6(3.3.4) in Wyszecki and Stiles (pp.145-146 second edition) to compute the point (xd,yd) associated with CCT.
   - First, define u = 1000/CCT.
   - If CCT < 7000, then xd = -4.6070 u^3 + 2.9678 u^2 + 0.09911 u +
   - 0.244063.
   - If CCT > 7000, then xd = -2.0064 u^3 + 1.9018 u^2 + 0.24748 u +
   - 0.237040.
   - In either case, yd = -3.000 xd^2 + 2.870 xd -0.275.

5. Convert (x,y) and (xd,yd) to u'v' coordinates:
   - (u',v') = (4x,9y)/(3 + 12y - 2x)
   - (u'd,v'd) = (4xd,9yd)/(3 + 12yd - 2xd)

6. Evaluate delta-u'v' between (u,v) and (ud,vd):

- delta-u'v' = sqrt[(u' - u'd)^2 + (v' - v'd)^2].

7. If delta-u'v' is greater than 0.01, display fails the test. Otherwise it passes the test.

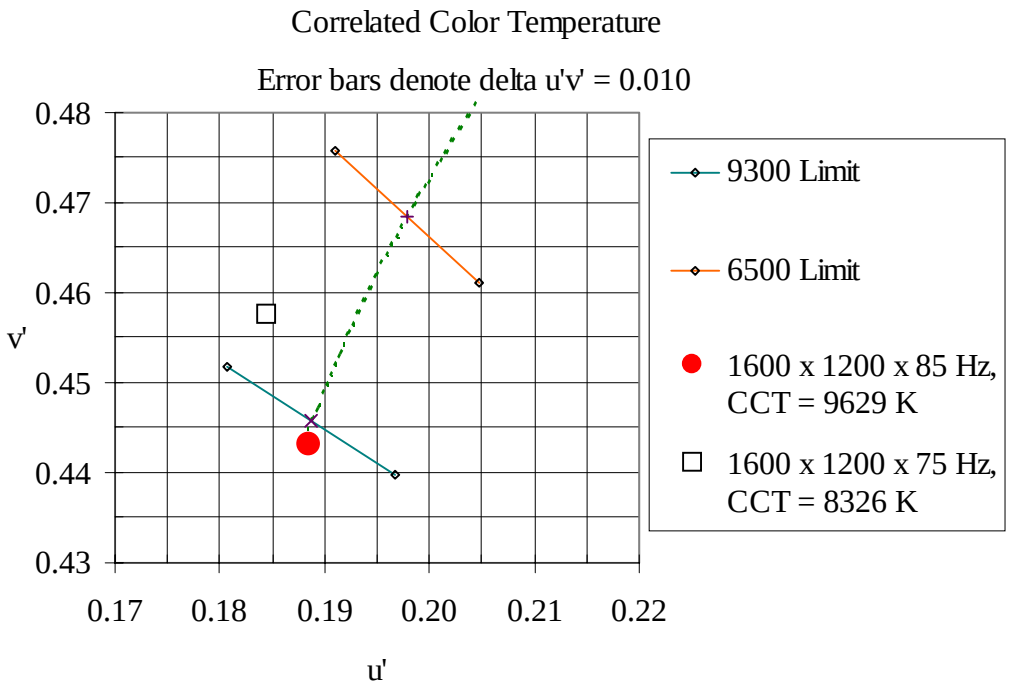


Figure II.5-1 *CCT of the measured whitepoint is within the boundaries required by IEC.*

Table II.5-1 Δu'v' Distances between measured whitepoints and CIE coordinate values from D_{65} to D_{93}.

		1600 x 1200
Vertical Refresh	75 Hz	85 Hz
CIE x	0.287	0.281
CIE y	0.316	0.293
CIE u'	0.185	0.189
CIE v'	0.457	0.443
CCT	8326	9629
Δu'v'	0.008	0.003

II.6. Bit Depth

Not measured.

II.8. Luminance Step Response

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.8, p 7.

No video artifacts were observed signifying good electrical response for Lmax luminance value of 33.3 fL at the CRT. The monitor passes the IEC specification for electrical response.

Objective: Determine the presence of artifacts caused by undershoot or overshoot.

Equipment: Test targets, SMPTE Test Pattern RP-133-1991, 2-D CCD array

Procedure: Display a center box 15% of screen size at input count levels corresponding to 25%, 50%, 75%, and 100% of Lmax with a surround of count level 0. Repeat using SMPTE Test pattern

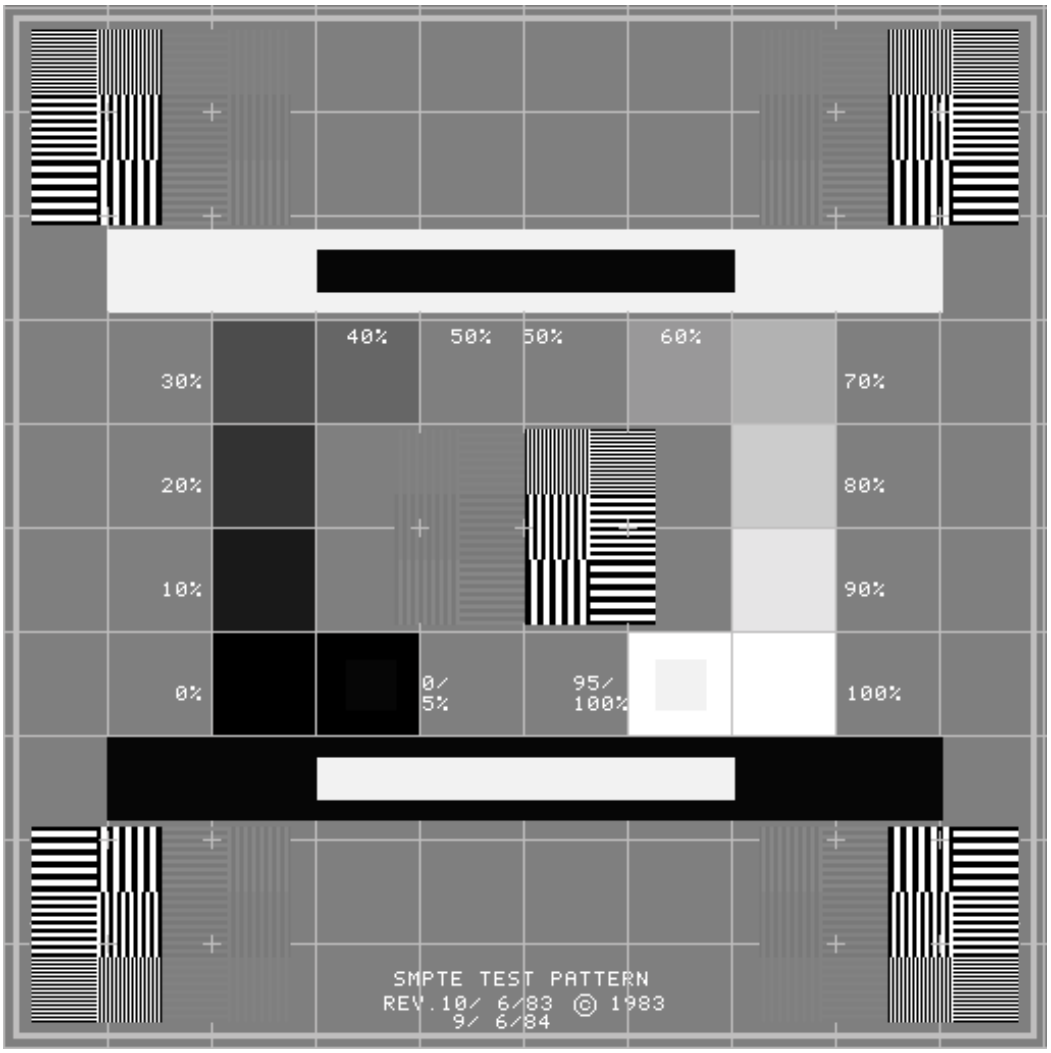


Figure II.8-1. SMPTE Test Pattern.

Data: Define pass by absence of noticeable ringing, undershoot, overshoot, or streaking.

The test pattern shown in Figure II.8-1 was used in the visual evaluation of the monitor. This test pattern is defined in SMPTE Recommended Practice RP-133-1986 published by the Society of Motion Picture and Television Engineers (SMPTE) for medical imaging applications. Referring to the large white-in-black and black-in-white horizontal bars contained in the test pattern, RP133-1986, paragraph 2.7 states " These areas of maximum contrast facilitate detection of mid-band streaking (poor low-frequency response), video amplifier ringing or overshoot, deflection interference, and halo." None of these artifacts was observed in the ViewSonic P815-4M monitor, signifying good electrical performance of the video circuits.

II.9. Addressability

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 6.1, p 67.

This monitor properly displayed all addressed pixels for the following tested formats (HxV): 1600 x 1200 x 85 Hz, and 1024 x 1024 x 110 Hz. The monitor passes the monoscopic addressability, but fails the IEC 1024 x 1024 pixel stereo specification because the vertical refresh rate cannot achieve 120 Hz.

Objective: Define the number of addressable pixels in the horizontal and vertical dimension; confirm that stated number of pixels is displayed.

Equipment: Programmable video signal generator.
Test pattern with pixels lit on first and last addressable rows and columns and on two diagonal lines beginning at upper left and lower right; H & V grill patterns 1-on/1-off.

Procedure: The number of addressed pixels were programmed into the Quantum Data 8701 test pattern generator for 75 Hz minimum for monoscopic mode and 110 Hz minimum for stereoscopic mode, where possible. All perimeter lines were confirmed to be visible, with no irregular jaggies on diagonals and, for monochrome monitors, no strongly visible moiré on grilles.

Data: If tests passed, number of pixels in horizontal and vertical dimension. If test fails, addressability unknown.

Table II.9-1 Addressabilities Tested

Monoscopic Mode	Stereo Mode
1600 x 1200	1024 x 1024

II.10. Pixel Aspect Ratio

Not measured.

II.11. Screen Size, Viewable Active Image

Not measured.

II.12. Contrast Modulation

Not measured for 1-pixel-On/1-pixel-Off. The contrast modulation for the raster lines on a full white screen is 65% at 50% Lmax and 36% at 100% Lmax.

II.13. Pixel Density

Not measured.

II.14. Moiré

Not measured.

II.15. Straightness

Not measured.

II.16. Refresh Rate

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.16, p 9.

Vertical refresh rate for 1600 x 1200 monoscopic format was set up to 85 Hz. Vertical refresh rate for the 1024 x 1024 stereo format was 110 Hz, limited by the monitor. The IEC specification is 120 Hz vertical refresh rate at 1024 x 1024 pixel addressability.

Vertical refresh rate for the 1152 x 864 stereo format used by Office of Americas was 128 Hz vertical, limited by the maximum horizontal scan rate (116 kHz) of the monitor when using the PC and Matrox G450 graphics card. The observed refresh rate in the GI system of 118 Hz maximum refresh rate may be limited by the SocetSet software.

Objective: Define vertical and horizontal refresh rates.

Equipment: Programmable video signal generator.

Procedure: The refresh rates were programmed into the Quantum Data 8701 test pattern generator for 72 Hz minimum for monoscopic mode and 120 Hz minimum for stereoscopic mode, where possible.

Data: Report refresh rates in Hz.

Table II.16-1 Refresh Rates as Tested

	Monoscopic Mode	**Stereoscopic Modes**	
Addressability	1600 x 1200	1152 x 864 *	1024 x 1024
Vertical Scan	85.0 Hz	128.9 Hz *	110 Hz
Horizontal Scan	106.250 kHz	116 kHz *	117.310 kHz

* ViewSonic P815-2M monitor, Serial number QE73402103 manufactured Aug. 1997.

II.17. Extinction Ratio (ZScreen)

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.17, p10.

Using the StereoGraphics ZScreen and passive glasses, stereo extinction ratio averaged 10.2 to 1 (11.4 left, 9.0 right) at screen center. Luminance of white varied by up to 12.8% across the screen. Chromaticity variations of white were less than 0.008 $\Delta u'v'$ units.

Using the StereoGraphics CrystalEyes active shutter glasses, stereo extinction ratio averaged 15.0 to 1 (15.3 left, 14.8 right) at screen center. The monitor passes the IEC specification for extinction ratio of color monitors.

Objective: Measure stereo extinction ratio

Equipment: Two “stereo” pairs with full addressability. One pair has left center at command level of 255 (or Cmax) and right center at 0. The other pair has right center at command level of 255 (or Cmax) and left center at 0.

Stereoscopic-mode measurements were made using a commercially-available Nuvision 19-inch LCD shutter with passive polarized eyeglasses.

Procedure: Calibrate monitor to 0.1 fL Lmin and 35 fL Lmax (no ambient). Measure ratio of Lmax to Lmin on both left and right side images through the stereo system.

Data: Extinction ratio (left) = L (left,on, white/black)/left,off, black/white)

L(left,on, white/black) ~ trans(left,on)*trans(stereo)*L(max)*Duty(left)
+ trans(left,off)*trans (stereo)*L(min)*Duty (right)
Use left,off/right,on to perform this measurement

Extinction ratio (right) = L (right,on,white/black)/right,off, black/white)

L(right,on, white/black) ~
trans(right,on)*trans(stereo)*L(max)*Duty(right)
+ trans(right,off)*trans (stereo)*L(min)*Duty (left)
Use left,on/right,off to perform this measurement

Stereo extinction ratio is average of left and right ratios defined above.

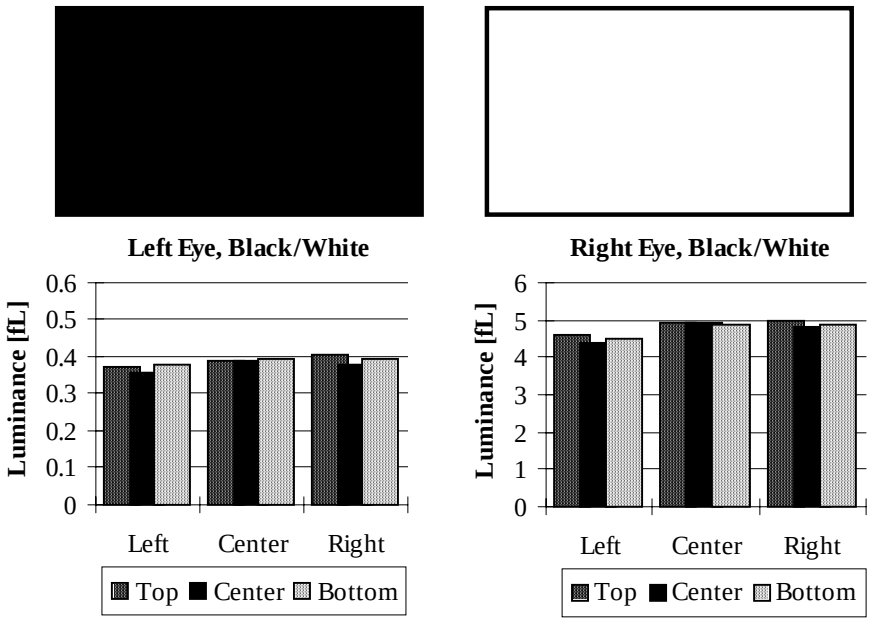


Fig.II.17-1. Spatial uniformity of luminance in stereo mode when displaying black to the left eye while displaying white to the right eye through the ZScreen and passive glasses.

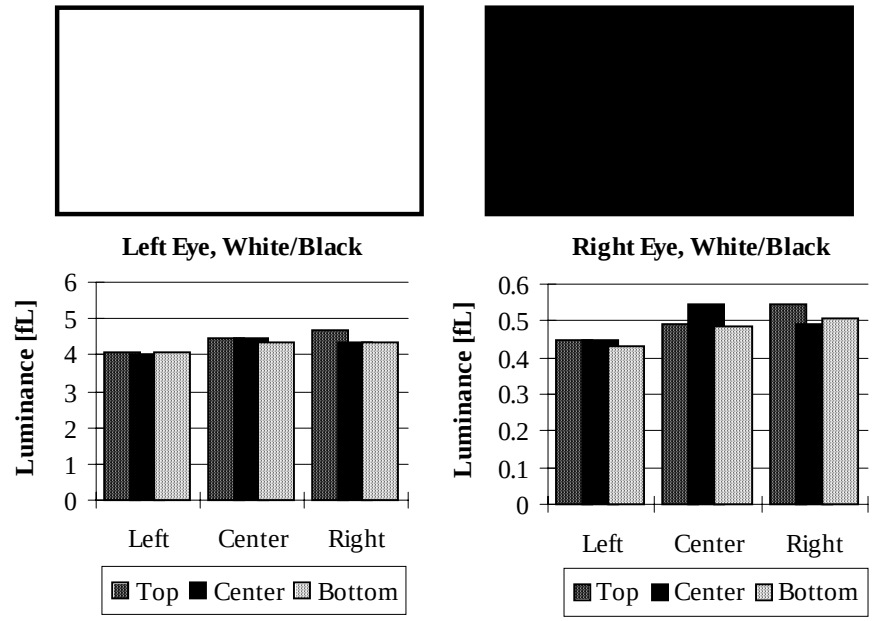


Fig.II.17-2. Spatial uniformity of luminance in stereo mode when displaying white to the left eye while displaying black to the right eye through the ZScreen and passive glasses.

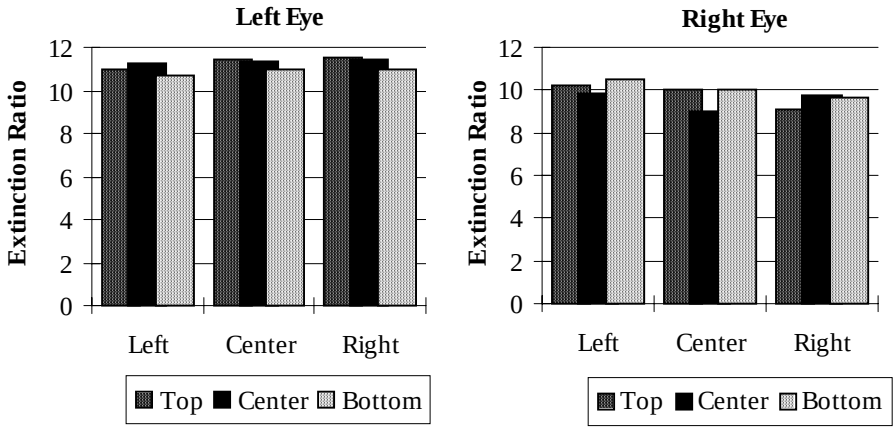


Fig.II.17-3. Spatial uniformity of extinction ratio in stereo mode as viewed through the ZScreen and passive glasses.

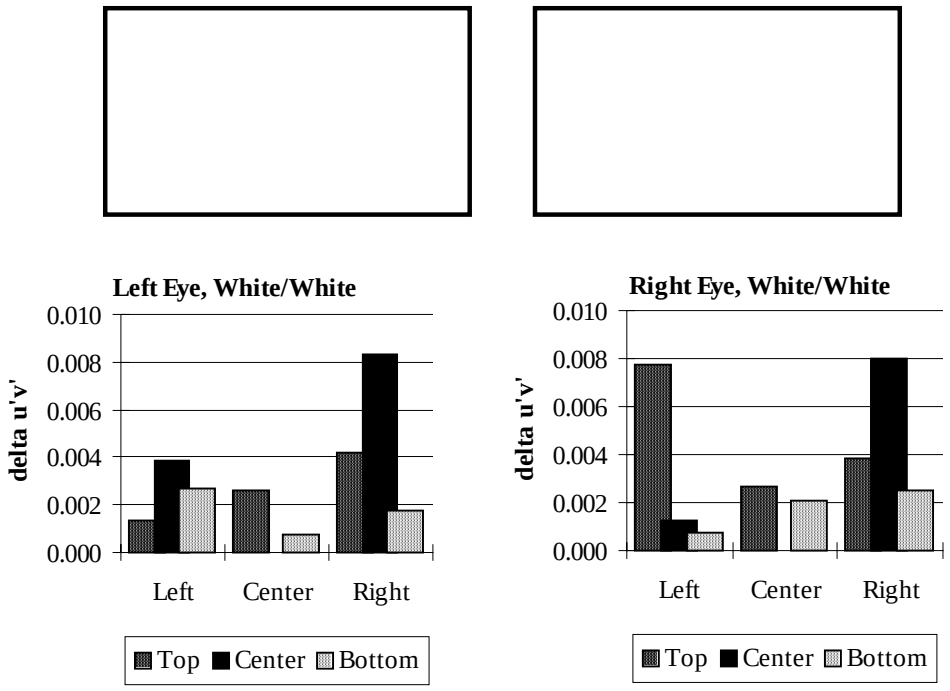


Fig.II.17-4 Spatial uniformity of chromaticity of white in stereo mode as viewed through the ZScreen and passive glasses.

II.18. Linearity

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 6.2, p 73.

The maximum nonlinearity of scan for the 1600 x 1200 monoscopic mode was 0.82% of full screen and does meet the IEC requirement of 1.0% or less.

Objective: Measure the relation between the actual position of a pixel on the screen and the commanded position to quantify effects of raster nonlinearity. Nonlinearity of scan degrades the preservation of scale in images across the display.

Equipment:
- Video generator
- Spatially calibrated CCD or photodiode array optic module
- Calibrated X-Y translation stage

Test Pattern: Use grille patterns of single-pixel horizontal lines and single-pixel vertical lines displayed at 100% L_{max}. Lines are equally spaced in addressable pixels. Spacing must be constant and equal to approximately 5% screen width and height to the nearest addressable pixel as shown in Figure II.18-1.

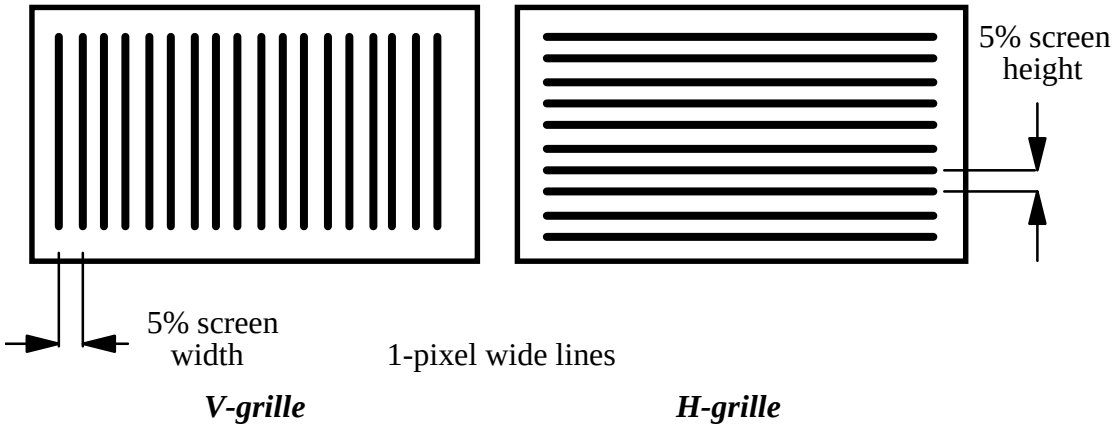


Figure II.18-1. Grille patterns for measuring linearity

Procedure: The linearity of the raster scan is determined by measuring the positions of lines on the screen. Vertical lines are measured for the horizontal scan, and horizontal lines for the vertical scan. Lines are commanded to 100% Lmax and are equally spaced in the time domain by pixel indexing on the video test pattern. Use optic module to locate center of line profiles in conjunction with x, y-translation stage to measure screen x, y coordinates of points where video pattern vertical lines intersect horizontal centerline of screen and where horizontal lines intersect vertical centerline of the CRT screen as shown in Figure II.18-2.

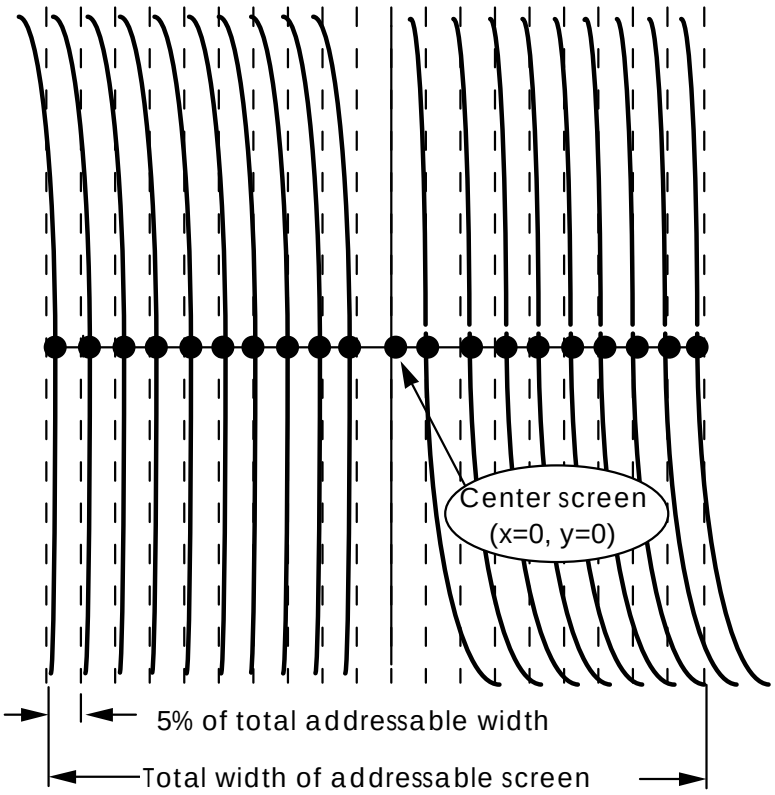


Figure II.18-2. Measurement locations for horizontal linearity along the major axis of the display. Equal pixel spacings between vertical lines in the grille pattern are indicated by the dotted lines. The number of pixels per space is nominally equivalent to 5% of the addressable screen size.

Data: Tabulate x, y positions of equally spaced lines (nominally 5% addressable screen apart) along major (horizontal centerline) and minor (vertical centerline) axes of the raster. If both scans were truly linear, the differences in the positions of adjacent lines would be a constant. The departures of these differences from constancy impacts the absolute position of each pixel on the screen and is, then, the nonlinearity. The degree of nonlinearity may be different between left and right and between top and bottom. The maximum horizontal and vertical nonlinearities (referred to full screen size) are listed in table II.18-1. The complete measured data are listed in table II.18-2 and shown graphically in Figure II.18-3.

Table II.18-1. Maximum Horizontal and Vertical Nonlinearities

Format	Left Side	Right Side	Top	Bottom
1600 x 1200	-0.51%	0.82%	0.22%	-0.74%

Table II.18-2. Horizontal and Vertical Nonlinearity Data for the 1600 x 1200 Monoscopic Mode

Vertical Lines x-Position (mils)		Horizontal lines y-Position (mils)	
Left Side	Right Side	Top	Bottom
-7756	7799	5751	-5810
-6991	7039	5161	-5222
-6203	6251	4579	-4638
-5426	5466	3998	-4054
-4642	4671	3423	-3471
-3861	3882	2847	-2889
-3078	3092	2277	-2312
-2304	2315	1706	-1734
-1534	1537	1144	-1156
-769	767	569	-576
0	0	0	0

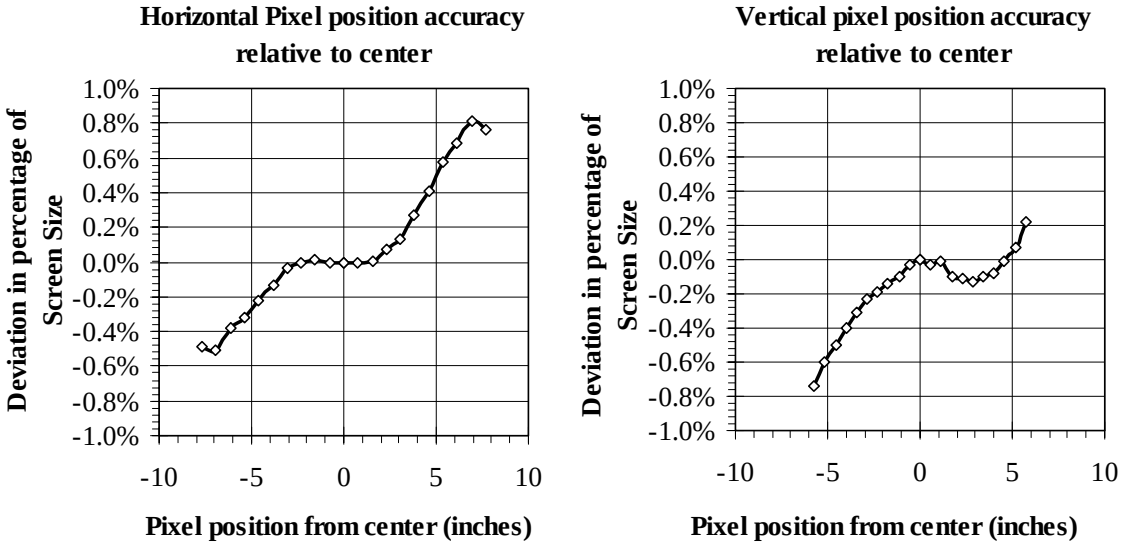


Fig. II.18-5 Horizontal and vertical linearity characteristics for the 1600 x 1200 monoscopic mode.

II.19. Jitter/Swim/Drift

Not measured.

II.20. Warm-up Period

Not measured.

II.21. Raster Modulation

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 5.2, p 57.

Center screen contrast modulation (Cm) in the vertical direction across the raster lines of a full white screen displayed at 50% Lmax was Cm = 65% and was Cm = 36% at Lmax. Raster line modulation is an indicator of the size of the electron beam spot. There is no IEC specification for white screen raster modulation, but the above values indicate good monitor performance.